TITLE OF THE INVENTION
A METHOD OF FABRICATING COMPOSITE TUBULAR DOOR FRAME

BACKGROUND OF THE INVENTION

This invention relates generally to a method of forming frame, and in particular, a fabricating method for composite tubular door frame for aerospace.

A plurality of complex composite parts for aerospace are usually made of a number of parts which can be assembled with each others using adhesive or mechanical fasteners. One such example is door frame made for helicopter, which is made normally of two or three pieces. These parts are prefabricated individually before these parts are fastened or riveted together. As for making a hollow frame, a few parts are bonded due to technical reasons as it is technically difficult to form a hollow frame as a single unit.

US Patent No. 5,579,618 patented by Harry M. Riegehman on February 20, 1996 discloses a unitary composite frame member of two or more structural element. The member has high structural strength, low thermal transmittance and low cost, and can be constructed by forming a metal strip into a U-channel, passing the U-channel through a plastic extruder for coating the steel strip with plastic in a thickness that increases the strength of the member, and sawing through the coating and U-channel between the legs of the U-channel, for substantially reducing thermal transmittance of the frame.

US Patent No. 4,974,366, issued to S Tizzoni on December 4, 1990, discloses a frame construction for a wall opening which includes a rigid metallic member adapted to be secured along a length of a wall defining the wall opening. The metallic member comprises first and second elongated spaced apart members each having first and second longitudinal free edges forming a channel configuration at least partly open-ended towards the wall opening between said first free edges. An insulating strip means is provided to extend between the first free edges of the spaced apart members in order to close the open end of the channel configuration and to define an elongated cavity therein. An insulating structural filler material is provided in the elongated cavity, whereby a thermal barrier is provided in the frame construction between the first and second spaced apart members which are separated by the insulating strip means and the structural filler material. The frame construction is thus adapted to receive a leaf hinge thereon while maintaining the thermal barrier. The leaf hinge is positioned to at least partly

overlie the insulating strip means and is fastened to the frame construction by way of screws passing through the insulating strip means and threadingly engaging the structural filler material, the hinge being spaced from at least one of the first and second spaced apart members of the metallic member in order to maintain the thermal barrier. Particularly, this patent discloses a thermally insulated aluminum door frame.

U.S. Pat. No. 4,344,254, issued on Aug. 17, 1982 to Varlonga, discloses a door frame provided with an uninterrupted heat insulating barrier positioned between two distinct metal sub-frames forming into a fixed framework mounted to the wall. The structure of the door frame constructed is rather complicated, and further, a conventional hinge could not be secured properly to the frame for the reason that the hinge would have to be mounted to tubular sections of the framework. If a plurality of screws are used to fasten a leaf hinge to the jambs, these screws might be engaged through a thin metal sheet of the jamb and a major portion of the threads thereof being provided no function but just thus hanging in cavities of the tubular sections.

In view of the above, it is an object of the present invention to provide a method of fabricating composite tubular door frame, which mitigates the drawbacks of the existing door frame.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a method of fabricating composite tubular door frame comprising the steps of

(a) laying-up a plurality layers of prepreg composite fabrics on a mould having an upper mould component and a lower mould component, and each layer of the composite fabric being compacted;

(b) placing a plurality of nylon tubes over the composite fabric at the upper mould component with the ends of the nylon tubes being extended out at each of the corners of the mould to be sealed with a main bag placed over the top and envelope the upper mould component;

(c) proceeding the mould to a curing step with a curing pressure of 4 to 7 bars with 0.3 to 0.7 bar vacuum, the mould being heated in an autoclave to 80 degree C and hold for 30 min to 1.5 hour with 0.3 to 0.7 bar of vacuum in the enclosure enveloped the main bag sealed with the nylon

tubes; and raising the temperature to 180 degree C and hold for 2 hours before cooling to room temperature; and

(d) removing the main bag from the mould and the nylon tubes being pulled out of from the mold and removing the mould to obtain a tubular door frame.

Yet another object of the present invention is to provide a method of fabricating composite tubular door frame, wherein the fabricated door frame is a unitary piece and can be in any shape or configuration.

A further object of the present invention is to provide a method of fabricating composite tubular door frame, wherein the unneeded material is trimmed off to form a smooth unitary piece.

Yet a further object of the present invention is to provide a method of fabricating composite tubular door frame, wherein the lower mould component is provided with opening so that the nylon tubes can be withdrawn from the fabricated frame in the course of de-moulding.

Yet another object of the invention is to provide a method of fabricating composite tubular door frame for which the cost of manufacturing is low and the fabricated door frame is durable.

Another object of the present invention is to provide a method of fabricating composite tubular door frame, wherein the composite fabric is pre-impregnated with epoxy resin.

DESCRIPTION OF THE DRAWINGS

These and other advantages will become more apparent from the detailed description of the preferred embodiment along with the following drawings:

Fig. 1 is an exploded perspective view of a mould for the method of fabricating composite tubular door frame in accordance with the present invention.

Fig. 2 is a cross sectional view of the mould in accordance with the present invention, dotted line being the position of the top mould component in the course of autoclaving process.

Fig. 3(a) is a cross sectional view of the mould showing the composite fabric being laid and the position of the nylon tubes in accordance with the present invention.

Fig 3(b) is a cross sectional view of the mould showing the position of the nylon tubes being positioned and enveloped by the composite fabric when the

upper mould component is closed with the lower mould component, before vacuuming or autoclave pressure, in accordance with the present invention

Fig. 4 is a perspective view of the lower mould component of the mould, showing composite fabric being laid-up thereon, in accordance with the present invention.

Fig. 5 is a cross sectional view of a closed mould, showing the nylon tube being inflated when vacuum is applied, in accordance with the present invention.

Fig. 6 is a schematic perspective of the mould showing the sealing tape path at the corner of the mould where the main bag and the nylon tube meets, in accordance with the present invention.

Fig. 7 shows a cure cycle chart in accordance with the method of the present invention.

Fig. 8 schematically shows the removal of the nylon tubes from the mould, via openings provided at the corners of the mould, in accordance with the present invention.

Fig. 9 is an exploded perspective view showing the removal of a fabricated door frame from the mould by opening the upper mould component from the lower mould component in accordance with the present invention.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

The preferred embodiment of the present invention is illustrated in the accompanying drawings. As seen in the FIG. 1, there is shown a mould having an upper mould component 12 and a lower mould component 14 having provided with opening 141 along the edges thereof. In the present preferred embodiment, a substantially rectangular door frame is to be fabricated and therefore, the mould including the upper mould component 12 and the lower mould component 14 is substantially rectangular in shape.

Fig. 2 illustrates cross sectional views of the upper mould component 12 and the lower mould component 14 in accordance with the present invention. In the course of fabricating a door frame of the present invention, the upper mould component 12 and the lower mould component 14 are closed together. The dotted line 12' indicates the position of the upper mould components 12.

Turning now to Fig. 3(a), there is schematically shown the composite fabric 30 being laid and the position of nylon tubes 32 in the opening 141 of the lower mould component 14 in accordance with the present invention. The composite

fabric 30 can be either carbon or glass fabric. Other examples of the composite fabrics 30 are boron and aramid. The composite fabric 30 is laid respectively on the interior of the upper mould component 12 and that of the lower mould component 14 in such a way that the composite fabric 30 on each of the mould components 12, 14 forms into an enclosure when the mould components 12,14 are closed. In accordance with the present invention, the nylon tubes 32 are placed within the upper mould component 12 next to the fabric 30 on the upper mould component 12. The nylon tubes 32 are deflated within the mould 12, 14. A temporary mould 16 is joined to the upper mould 14 to shape the lay-up of the composite fabric 30 and is removed before closing the mould 12, 14. Fig 3(b) is a cross sectional view of the mould showing the position of the nylon tubes 32 being positioned and enveloped by the composite fabric 30 when the upper mould component 12 is closed with the lower mould component 14, before vacuuming or autoclave pressure, in accordance with the present invention.

Fig. 4 is a perspective view of the lower mould component 14 of the mould, showing composite fabric 30 being laid-up thereon, in accordance with the present invention.

In the preferred embodiment, the composite fabric for lay-up in the mould 12, 14 is pre-impregnated with epoxy resin and are cut separately for mounting onto the upper mould component 12, and the lower mould component 14. Each layer of the composite fabric 30 are placed in accordance with the fabric orientation required in the door frame design. The numbers of layers of the composite fabric 30 are depending on the structural strength requirement and a plurality of layers of composite fabric 30 are needed if a higher strength of door frame is required. As shown in Fig. 3, four layers of composite fabric 30 are laid. With the application of the temporary mould 16, shown in Fig. 3, which is secured onto the upper mould component 14, the lay-up of composite fabric 30 is facilitated. In the course of lay-up of composite fabric 30, each layer of the composite fabric 30 is compacted by sealing with a nylon bag (not shown) similar to the main bag 50 (referring to Fig. 5) and applying vacuum.

In accordance with the present invention, a plurality of nylon tubes 32 are placed at the upper mould component 14 on each side of the composite fabric 30. The nylon tubes 32 extend out of the lower mould component 14 at each corner thereof so that the nylon tubes 32 can be sealed with the main bag 50 placed over the upper mould component 12 and enveloped the entire upper mould component

12. Referring to Fig. 5, there is shown a cross sectional view of a closed mould 12, 14, showing the nylon tube 32 being inflated when vacuum is applied, in accordance with the present invention. The nylon tubes 32 are used for pressurization of the inner wall of the composite fabric 30. As shown in Fig. 6, sealing tape 52 are placed around the edge of the lower mould component 14, all over the opening 141 at the corners of the lower mould component 14, and connecting to the nylon tubes 32 to envelope and seal the entire composite fabric 30 lay-up. A plurality of vacuum ports (not shown) are placed at suitable location of the main bag 50 and vacuum is applied on the mould 12, 14, as shown in Figs. 5, and 6, which is a schematic perspective of the mould 12, 14 showing the sealing tape 52 path at the corner of the mould 12, 14 where the main bag 50 and the nylon tubes 32 meets, in accordance with the present invention.

The mould 12, 14 of the present invention is then proceeded to curing. Depending on the composite fabric 30 used, in the present preferred embodiment, the mould 12, 14 is cured either at 180 degree C or 120 degree C. The cure pressure is ranging from 4 to 7 bars with 0.3 to 0.7 bar vacuum, preferably at 4 bars with 0.5 bar vacuum. Fig. 7 shows a cure cycle chart in accordance with the method of the present invention. The mould 12, 14 is heated in an autoclave to 80 degree C and hold for 30 minutes to 90 minutes, preferably, 60 minutes with 0.3 to 0.7 bar, preferably, 0.5 bar of vacuum in the enclosure enveloped the main bag 50 sealed with the nylon tubes 32. A pressure of 4 bars is applied in the autoclave during the 80 degree C soaking time. After that, the temperature is gradually increased to 180 degree C and hold for 2 hour before the mould 12, 14 is cooled to room temperature.

Turning now to Fig. 8, there is shown the removal of the nylon tubes 32 from the mould 12, 14, via openings 141 provided at the corners of the mould 12, 14, in accordance with the present invention. The nylon tubes 32 are pulled out of the mould 12, 14.

Fig. 9 is an exploded perspective view showing the removal of a fabricated door frame 100 from the mould 12, 14 by opening the upper mould component 12 from the lower mould component 14 in accordance with the present invention.

In the present invention, a trimming step can be employed to trim excessive material off from the fabricated door frame 100. The door frame 100 thus obtained has a hollow interior and is a unitary piece with high structural strength for various applications.

Although the present invention has been described with respect to details of embodiment, it is not intended that such details be limitations upon the scope of the invention. It will be obvious to those skilled in the art that various modifications, such as varying of shapes of the door frame, and substitutions may be made without departing from the spirit and scope of the invention as set forth in the following claims.